NISTTech

Comb-Generating Optical Cavity with Optical Amplifier & Modulator

Awarded the 2005 Nobel Prize for Physics

Description

This invention provides a highly selective Optical Frequency Comb (OFC) generator which can coherently bridge a wide frequency interval of more than a few terahertz (THz); for example, 4 THz. The OFC comprises a plurality of equally-spaced spectral lines that are grouped around the reference spectral line established by the carrier frequency laser. The novel features include the provision of an intercavity optical amplifier, such as an optical parametric amplifier, within the comb-generating cavity.

Advantages

- **Broad range**
  The system currently spans 125,000 frequency components of light, or 100 nanometers (750-850 nm) in the visible and near-infrared wavelength range, enabling scientists to observe all the energy levels of a variety of different atoms and molecules simultaneously.
- **High resolution**
  High resolution or precision allows scientists to separate and identify signals that are very brief or close together, such as individual rotations out of hundreds of thousands in a water molecule. The resolution can be tweaked to reach below the limit set by the thermal motion of gaseous atoms or molecules at room temperature.
- **Greater sensitivity**
  High sensitivity—currently 1 molecule out of 100 million—enables the detection of trace amounts of chemicals or weak signals. With additional work, the JILA team foresees building a portable tool providing detection capability at the 1 part per billion level.
- **Enabling real-time observations**
  A fast data-acquisition time of about 1 millisecond per 15 nm of bandwidth enables scientists to observe what happens under changing environmental conditions, and to study molecular vibrations, chemical reactions, and other dynamics.

Abstract

A low-loss comb-generating optical cavity including an optical amplifier and a microwave-driven electro-optic modulator crystal, produces a comb of optical frequency sidebands having spectral lines equally spaced around the frequency of an input laser beam incident on the comb-generating cavity. The comb-generating cavity includes an input mirror movable along the beam propagation direction, and a fixed position output mirror located at time synchronous distances of both the input laser wavelength and modulation wavelength. The comb-generating cavity and its microwave driven modulator are in resonance with the input laser beam, and provide iterative or recirculating beam action that transfers the input optical frequency of the laser, sideband by sideband, to remote and precisely known comb frequencies offset from, and centered on, the input laser frequency. Optical parametric amplification within the comb-generating cavity extends the sideband or comb spectrum and sharpens the time domain impulse represented by the cavity circulating fields. A relatively short bandpass filter optical cavity receives the comb output of the comb-generating cavity and is made up of the fixed-position mirror and a third mirror movable along the beam propagation direction. Fine movement of the third mirror tunes the bandpass filter cavity, and preferentially couples out the power of one or more comb frequencies. An optional input optical cavity at the input side may increase efficiency. A self-oscillating configuration provides optical parametric oscillation.

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Citations

1. S. A. Diddams, D.J. Jones, J.Ye, S.T. Cundiff, F.L. Hall. Direct Link between Microwave and Optical Frequencies with a 300 THz Femtosecond Laser Comb, Physical Review Letters. Vol. 84, No. 22, May 29, 2000.
2. J.D. Jost, J.L. Hall, J. Ye, Continuously tunable, precise, single frequency optical signal generator, Optics Express, Vol. 10, No. 12, June 17, 2002.
3. J.L. Hall, Nobel Lecture- Defining and Measuring Optical Frequencies, Reviews of Modern Physics, Vol. 78, Oct-Dec 2006.

Related Items

- Optical Frequency combs
- Article: Record-setting Laser May Aid Searches for Earthlike Planets
- Article: Optical ‘Frequency Comb’ Can Detect the Breath of Disease

- Optical Comb Offers Laser Reference

References

- NIST Docket 97-048, U.S. Patent # 6,201,638 issued 03-13-2001

Status of Availability

This invention is available for licensing exclusively or non-exclusively in any field of use.

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